

Effect of destabilizing fields on hydrodynamic instabilities in nematics

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Abstract. The effect of destabilizing fields on the roll instability (RI) threshold for shear flow and on the homogeneous instability (HI) threshold for plane Poiseuille flow of nematic HBAB ($\mu_3 > 0$) is studied on the basis of the continuum theory of nematics for flow cells of infinite lateral width. It turns out that the critical shear rate and wave vector at RI threshold decrease with increasing destabilizing field but do not approach zero at the Freedericksz transition. However calculations show that beyond the Freedericksz threshold HI may be favourable over a range of destabilizing field with shear in the stabilizing role. For plane Poiseuille flow a similar analysis points to the existence of a HI threshold in the presence of destabilizing field beyond the Freedericksz threshold again with shear acting as a stabilizing field. These results are compared with theoretical results obtained previously for MBBA.

Keywords. Roll instability; nematics; MBBA; HBAB; homogeneous instability; shear flow; plane Poiseuille flow.

1. Introduction

Homogeneous (HI) and roll instabilities (RI) have been the subject of theoretical and experimental study. Pieranski and Guyon (1973) observed and measured the HI threshold for shear flow in MBBA and gave a simple theoretical analysis based on the continuum theory. Subsequently they found (Pieranski and Guyon 1974a) that in the presence of large stabilizing fields RI is more favourable than HI and gave a simple theoretical picture of the RI involving *hydrodynamic focussing*. Leslie developed rigorous solutions for HI and independently Manneville and Dubois-Violette (1976a) also did the same but extended their study to RI. They pointed out that HI cannot occur in a nematic with $\mu_3 > 0$ (μ_3 is an Ericksen-Leslie coefficient) and also studied effects of stabilizing fields on HI and RI. More recently the effects of destabilizing fields on HI were studied (Kini 1978) on the basis of the approach taken by Leslie (1976). Approximate solutions obtained by Dubois-Violette and Manneville (1978) for RI and HI in cylindrical Couette flow re-emphasized the possibility of observing RI in nematics with $\mu_3 > 0$. However effects of destabilizing fields on RI in such nematics have not been studied.

Pieranski and Guyon (1974b, 1975) reported theoretical and experimental studies on the plane Poiseuille flow of MBBA. They indicated theoretically the existence of the Twist and Splay-modes of which they observed only the former. Janossy *et al* (1976) gave a simple analysis of the HI and experimentally established the occurrence of net secondary flow with the Twist mode. Manneville and Dubois-Violette